

LIGHT SOURCE MONITORING APPARATUS

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1 LIGHT SOURCE MONITORING APPARATUS

2
3 CROSS REFERENCE TO RELATED APPLICATION
4

5 This application claims the benefit of U.S.
6 Provisional Application No. 60/275,091, filed 12 March
7 2001.

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9 FIELD OF THE INVENTION
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11 This invention relates to light sources used in
12 optoelectric modules and the like.
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14 More particularly, the present invention relates to
15 light source monitoring apparatus used in optoelectric
16 modules and other electronic equipment.

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19 BACKGROUND OF THE INVENTION
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21 In optical-to-electrical and electrical-to-optical
22 (hereinafter "optoelectric") modules used in the various
23 communications fields, one of the most difficult problems
24 that must be solved is the efficient transmission of light

1 between a light generating device and an optical fiber or,
2 alternatively, the transmission of light from the optical
3 fiber to a light receiving device. Here it will be
4 understood by those skilled in the art that the term
5 "light" is a generic term which includes any
6 electromagnetic radiation that can be modulated and
7 transmitted by optical fibers or other optical transmission
8 lines.

9
10 Because of light losses due to misalignment of optical
11 components and other losses in the system, it is often
12 necessary to drive light sources, such as lasers, light
13 emitting diodes, etc. harder (i.e., provide more current)
14 to provide sufficient light for proper operation. Also,
15 because of minor changes in alignment of components,
16 differences in components (although they may still be
17 within a specified tolerance), ageing of components and
18 especially the light source itself, and other factors, it
19 is often necessary to change the amount of drive to the
20 light sources between similar optoelectric apparatus and in
21 a specific apparatus over a lifetime. For example, it is
22 well known in the art that the light output of
23 semiconductor lasers (including vertical cavity surface

1 emitting lasers 'VCSELs', edge emitting lasers, etc.)
2 varies with changes in conditions.

3

4 It is understood by those skilled in the art that too
5 much drive to a light source results in wasted power,
6 overheating, reduced life cycle, and other problems.
7 However, too little drive to a light source results in
8 improper operation, possible loss of information in data
9 systems, random errors, and many other problems. Thus, it
10 is highly desirable to provide drive to light sources that
11 is as close to optimum as possible. To achieve this result
12 it is generally desirable to continuously monitor the
13 output of the light source to ensure a constant level of
14 light output. A variety of light source monitors have been
15 proposed in the prior art. However, these prior art
16 monitoring systems are generally complicated and expensive
17 to incorporate into optoelectric modules and other
18 apparatus.

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20 It would be highly advantageous, therefore, to remedy
21 the foregoing and other deficiencies inherent in the prior
22 art.

1 Accordingly, it is an object the present invention to
2 provide new and improved light source monitoring apparatus.

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4 Another object of the present invention is to provide
5 new and improved light source monitoring apparatus which
6 uses a minimum number of components in the system.

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8 And another object of the present invention is to
9 provide new and improved light source monitoring apparatus
10 which improves the efficiency of optical systems.

11

12 Still another object of the present invention is to
13 provide new and improved light source monitoring apparatus
14 which allows the use of a variety of components and
15 component materials.

1 SUMMARY OF THE INVENTION

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3 Briefly, to achieve the desired objects of the present
4 invention in accordance with a preferred embodiment
5 thereof, provided is light source monitoring apparatus
6 including a light source designed to produce a beam of
7 light. The light source includes drive electronics
8 connected to the light source to supply a desired amount of
9 drive current to the light source. A monitor diode is
10 connected to the drive electronics to control the amount of
11 drive current supplied to the light source by the drive
12 electronics. A lens system is positioned to receive the
13 beam of light from the light source and transmit
14 substantially all of the beam of light to a light terminal.
15 The lens system includes an optical element and a light
16 reflecting surface on the optical element positioned to
17 reflect a portion of the beam of light onto the monitor
18 diode.

19

20 In a preferred embodiment the lens system includes a
21 pair of lens elements defining an optical axis and
22 directing light from the light source into an optical
23 fiber. A first of the lens elements is positioned along
24 the optical axis adjacent the light source and a second of
25 the lens elements is positioned along the optical axis
26 adjacent the light terminal. The light reflecting surface

1 can be, for example, the back of the second lens element or
2 it can be a third optical element and positioned along the
3 optical axis and between the first and second lens elements
4 to reflect a portion of the beam of light at an angle to
5 the optical axis onto the monitor diode. Further, the
6 first and second lens elements (and the adjacent light
7 source and light terminal, respectively) can be housed in
8 separate structural portions that are later assembled to
9 form a complete unit.

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BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and further and more specific objects and advantages of the invention will become readily apparent to those skilled in the art from the following detailed description of a preferred embodiment thereof, taken in conjunction with the drawings in which:

FIG. 1 is a sectional view of a simplified optoelectric module including an embodiment of a light source monitoring system in accordance with the present invention; and

FIG. 2 is an enlarged sectional view of a portion of an optoelectric module including another embodiment of a light source monitoring system in accordance with the present invention.

1 DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

2

3 The present invention pertains to new and improved
4 light source monitoring apparatus for telecommunication and
5 data communication apparatus and the like and in particular
6 for optoelectric modules. Turning to FIG. 1, a sectional
7 view is illustrated of a simplified optoelectric module 10
8 in accordance with the present invention. As stated above,
9 the term "optoelectric" is used herein to denote the fact
10 that module 10 can be either an optical-to-electrical or
11 electrical-to-optical module and will generally, include
12 both channels. It will be understood that, since light
13 source monitoring apparatus is being disclosed, the major
14 use of light sources is in the electrical-to-optical
15 portion of the module, which applies to opposite ends of
16 both channels.

17

~~18 Module 10 of FIG. 1 includes a receptacle assembly 11~~
19 and an optoelectric package 12 each forming a separate
20 structural portion of module 10. After fabrication,
21 receptacle assembly 11 and optoelectric package 12 are
22 aligned and affixed together, as will be disclosed in more
23 detail below. Receptacle assembly 11 is designed to
24 receive an optical fiber 14 in communication therewith, in
25 a manner that will become clear presently. In the
26 preferred embodiment, optical fiber 14 is a single mode

1 fiber (the use of which is one of the major advantages of
2 the present invention) including a glass core 15 and a
3 cladding layer 16. Receptacle assembly 11 includes an
4 elongated cylindrical ferrule 20 defining a fiber receiving
5 opening 21 at one end and a mounting flange 22 at the
6 opposite end.

7

8 Progressing from end 21 toward end 22, ferrule 20 has
9 two radially outwardly directed steps 32 and 33. Step 32
10 provides a surface or stop for the mounting of an optical
11 spacer 35 and step 33 provides a surface or a stop for the
12 positioning of an optical lens element or assembly 36. In
13 this preferred embodiment, lens assembly 36 is formed of
14 plastic and may be, for example, molded to simplify
15 manufacturing of module 10. It should be understood that
16 the term "plastic" is used herein as a generic term to
17 describe any non-glass optical material that operates to
18 transmit optical beams of interest therethrough and which

19 can be conveniently formed into lenses and the like. For
20 example, in most optical modules used at the present time
21 the optical beams are generated by a laser that operates in
22 the infra-red band and any materials that transmit this
23 light, including some oxides and nitrides, come within this
24 definition.

25

26 Lens assembly 36 defines a central opening for the
27 transmission of light therethrough from an end 37 to an

1 opposite end 38. A lens 39 is integrally formed in the
2 central opening a fixed distance from end 38. In this
3 specific embodiment, lens assembly 36 is formed with
4 radially outwardly projecting ribs or protrusions in the
5 outer periphery so that it can be press-fit into ferrule 20
6 tightly against spacer 35.

7

8 Thus, lens assembly 36 is frictionally held in place
9 within ferrule 20 and holds spacer 35 fixedly in place.
10 Also, lens 39 is spaced a fixed and known distance from
11 spacer 35. In this preferred embodiment, optical fiber 14
12 is inserted into ferrule 20 so that glass core 15 butts
13 against spacer 35, which substantially reduces or
14 suppresses return reflections. Further, by forming spacer
15 35 of glass material with an index of refraction similar to
16 the index of refraction of glass core 15, spreading of the
17 light beam is substantially reduced and lower optical power
18 is required to collimate the beam.

19

20 Optoelectric package 12 includes a base or support
21 plate 40 and a mounting plate 42 positioned thereon. One
22 or more spacer rings 43 may be positioned on plate 42 to
23 provide sufficient distance for components mounted thereon.
24 A light source (hereinafter laser 45) is mounted on the
25 upper surface of mounting plate 42 and positioned to
26 transmit light generated therein to a lens element or block
27 46, including a curved reflecting lens surface 49. In this

1 embodiment, laser 45 may be, for example, any of the well
2 known lasers, light emitting diodes, etc. Lens block 46 is
3 mounted on mounting plate 42 by some convenient means, such
4 as outwardly extending ears (not shown). A ring 47 is
5 positioned on spacer rings 43 and a cap or cover 48 is
6 affixed to ring 47.

7

8 Generally, the entire assembly, including plate 40,
9 mounting plate 42, spacer rings 43, ring 47 and cover 48
10 are fixedly attached together by some convenient means,
11 such as welding, gluing, etc. so that laser 45 is enclosed
12 in a hermetically sealed chamber. However, a hermetic seal
13 is not necessary in many embodiments in which a laser or
14 photodiode are used that is either separately sealed or is
15 not sensitive to atmospheric conditions. Connections to
16 the electrical components discussed herein can be by
17 pigtail or by coupling through plate 40. Also, some
18 circuitry and connections can be incorporated into plate 40
19 and mounting plate 42, if desired.

20

21 Here it should be understood that fixing lens surface
22 49 relative to laser 45 accurately determines the distance
23 between lens surface 49 and laser 45. Also, fixing lens 39
24 to optical fiber 14 accurately determines the distance
25 between lens 39 and optical fiber 14. Because these are
26 short distances (on the order of microns), they can be
27 determined relatively accurately. However, the distance

1 between lens 39 and lens surface 49 is less critical, which
2 provides substantially relaxed tolerances for module 10 and
3 for the assembling thereof. The distance between lens 39
4 and lens surface 49 is not critical because the light is
5 collimated and slight variances in axial position simply
6 produce a small amount of light loss. Also, slight
7 differences in the relative positions along optical axis Z
8 have little or no effect.

9

10 A window 50 is sealed in cover 48 so as to be aligned
11 with lens block 46. Lens block 46 includes a curved
12 reflecting lens surface 49 that redirects light from laser
13 45 at a ninety degree angle out through window 50. While
14 window 50 is illustrated and described as a simple window
15 that allows the transmission of light therethrough, it will
16 be understood that it is an optical element that may
17 include one or more lenses or optical surfaces in specific
18 applications. Further, window 50 is affixed to the

19 underside of cover 48 by some convenient means, such as
20 epoxy or other adhesive, so as to hermetically seal the
21 light transmitting opening through cover 48. Generally,
22 and especially when a hermetic seal is not required, window
23 50 can be formed (e.g. molded) from plastic. In some
24 applications, lens block 46 may also be molded from plastic
25 for convenience in manufacturing. Also, in some
26 applications it may be convenient to provide a light source
27 (e.g. a VCSEL or LED) that emits directly along optical

1 axis Z, thereby omitting lens block 46 from the lens
2 system. In such a system it may be convenient to replace
3 window 50 with one or more lenses.

4

5 Optoelectric package 12 is affixed to receptacle
6 assembly 11 with flange 22 of ferrule 20 butting against
7 the upper surface of cover 48. Further, optoelectric
8 package 12 is optically aligned with receptacle assembly 11
9 so that light from laser 45 is directed into core 15 of
10 optical fiber 14 along optical axis Z. This alignment can
11 be accomplished in different ways but one reliable method
12 is known as active alignment. In this process, laser 45 is
13 activated and receptacle assembly 11 is positioned
14 approximately over optoelectric package 12. The light in
15 optical fiber 14 is measured and the alignment is adjusted
16 for maximum light. When maximum light is measured
17 alignment has been achieved and receptacle assembly 11 is
18 fixed to optoelectric package 12 by some convenient means,

19 such as welding or adhesive. Because of the separate
20 structural portions, in most applications this alignment
21 and assembly can be accomplished quickly and easily using
22 machines.

23

24 Module 10 includes light source monitoring apparatus
25 associated with laser 45. As stated above, because the
26 light output of semiconductor lasers (including vertical
27 cavity surface emitting lasers 'VCSELs', edge emitting

lasers, etc.) varies with changes in conditions, it is often desirable to include apparatus for measuring the output of the laser and using that measurement to adjust the laser to keep the output constant. In this embodiment, the light source monitoring apparatus includes a monitor diode 56 mounted on the surface of mounting plate 42. Here it will be understood that the term "monitor diode" represents any convenient electronic device (e.g., photodiode, pin diode, PN diode, etc.) capable of receiving light at the wavelength of interest and converting the received light to electrical signals representative of the strength or amount of received light.

Also, a light reflecting surface 58 is provided in the lens system of module 10 and positioned to reflect a portion of the beam of light from laser 45 onto monitor diode 56. In this specific embodiment, light reflecting surface 58 is formed as a portion of lens 39 in lens assembly 36. In this preferred embodiment, during the formation of lens assembly 36, lens 39 is formed with a substantially flat light inlet surface 58 that is tilted or angled slightly at an angle α with respect to optical axis Z. Angle α is adjusted, both in the amount of the angle and in the direction of the angle so that a constant amount of light is reflected. The amount of angle α of surface 58 is determined during fabrication of lens assembly 36 and

1 the direction of angle α can be adjusted during assembly by
2 rotating lens assembly 36 within ferrule 20.

3

4 Here it should be specifically noted that surface 58
5 is positioned a relatively long distance from lens block 46
6 (since this distance has little or no effect on the
7 operation of module 10) so that angle α is relatively small
8 and has a minimum effect on light traveling along optical
9 axis Z to optical fiber 14. That is, by minimizing angle α
10 the amount of light that is reflected from the main beam is
11 minimized and the efficiency of the entire system (module
12 10) remains high. In fact, in some applications, the light
13 inlet surface of lens 39 may be formed (e.g., convex or
14 concave) so that a small amount of natural reflection will
15 be received by monitor diode 56 and additional surfaces may
16 not be required to provide a reflecting surface.

17

18 Turning now to FIG. 2, an optoelectric package 12' of
19 a module 10' is illustrated including another embodiment of
20 light source monitoring system in accordance with the
21 present invention. Components in this embodiment which are
22 similar to components in the embodiment of FIG. 1 are
23 designated with similar numbers and all of the numbers have
24 a prime added to indicate the different embodiment.

25

26 Optoelectric package 12' includes a base or support
27 plate 40' and a mounting plate 42' positioned thereon. One

1 or more spacer rings 43' may be positioned on plate 42' to
2 provide sufficient distance for components mounted thereon.
3 A light source (hereinafter laser 45') is mounted on the
4 upper surface of mounting plate 42' and positioned to
5 transmit light generated therein to a lens element or block
6 46'. In this embodiment, laser 45' may be, for example, any
7 of the well known lasers, light emitting diodes, etc. Lens
8 block 46' is mounted on mounting plate 42' by some
9 convenient means, such as outwardly extending ears (not
10 shown). A ring 47' is positioned on spacer rings 43' and a
11 cap or cover 48' is affixed to ring 47'.

12
13 A window 50' is sealed in cover 48' so as to be
14 aligned with lens block 46'. Lens block 46' includes a
15 curved reflecting surface 49' that redirects light from
16 laser 45' at a ninety degree angle out through window 50'.

17 While window 50' is illustrated and described as a simple
18 ~~window that allows the transmission of light therethrough,~~
19 it will be understood that it is an optical element that
20 may include one or more lenses or optical surfaces in
21 specific applications.

22
23 Module 10' includes light source monitoring apparatus
24 associated with laser 45'. As stated above, because the
25 light output of semiconductor lasers (including vertical
26 cavity surface emitting lasers 'VCSELs', edge emitting
27 lasers, etc.) varies with changes in conditions, it is

1 often desirable to include apparatus for measuring the
2 output of the laser and using that measurement to adjust
3 the laser to keep the output constant. In this embodiment,
4 the light source monitoring apparatus includes a monitor
5 diode 56' mounted in a cavity 57' in mounting plate 42'.
6 Here it will be understood that the term "monitor diode"
7 represents any convenient electronic device (e.g.,
8 photodiode, pin diode, PN diode, etc.) capable of receiving
9 light at the wavelength of interest and converting the
10 received light to electrical signals representative of the
11 strength or amount of received light.

12
13 Also, a light reflecting surface 59' is provided in
14 the lens system of module 10' and positioned to reflect a
15 portion of the beam of light from laser 45' onto monitor
16 diode 56'. In this specific embodiment, light reflecting
17 surface 59' is the light inlet surface of window 50'. In
18 ~~this preferred embodiment, during the assembly of~~
19 optoelectric package 12', window 50' is tilted or angled
20 slightly at an angle with respect to optical axis Z. The
21 angle is adjusted so that a constant amount of light is
22 reflected onto monitor diode 56'. Here it will be
23 understood that slanted window 50' can be used with any of
24 the direct emitting light sources in which lens block 46'
25 is not used. Also, window 50' can be positioned at any
26 convenient distance from lens block 46' or the light source

1 to optimize the reflection angle and the amount of
2 unreflected light passing through window 50'.

3

4 While the amount of reflected light received by
5 monitor diode 56' is generally not critical, it is
6 desirable that the reflected light is a constant
7 percentage of the total light and sufficient to produce a
8 control signal. Thus, an angle can be determined
9 empirically and that angle can simply be built-into cover
10 48'. In some specific applications, the amount of the
11 angle can be adjusted during assembly by moving window 50'
12 within the opening in cover 48'. Also, in some specific
13 applications, window 50' can be fabricated with a slanted
14 light inlet surface.

15

16 In any of the above described light source monitoring
17 apparatus, the light source includes drive electronics,
18 ~~either internally or associated therewith (e.g. in an~~
19 electronic module) and connected to the light source to
20 supply an amount of drive current to the light source. The
21 monitor diode is connected to the drive electronics so as
22 to control the amount of drive current supplied to the
23 light source by the drive electronics. Thus, the amount of
24 light generated or produced by the light source can be
25 maintained constant over time and between different
26 modules.

1 Accordingly, new and improved light source monitoring
2 apparatus are disclosed which are capable of controlling a
3 light source to produce a constant output under varying
4 conditions and which, thereby, improve the efficiency of
5 optical systems. Because a pair of lenses are incorporated
6 that are fixed relative to a light source and a light
7 receiving structure, respectively, the distance along the Z
8 axis between the pair of lenses is not critical, which
9 allows the placement of a reflecting surface at a
10 convenient distance from the light source. Also,
11 manufacturing tolerances can be substantially reduced,
12 substantially reducing manufacturing time, labor, and
13 costs. Further, the new and improved optical alignment
14 features allow the use of a variety of components and
15 component materials (e.g. plastic lenses and other optical
16 components).

17
18 Various changes and modifications to the embodiments
19 herein chosen for purposes of illustration will readily
20 occur to those skilled in the art. To the extent that such
21 modifications and variations do not depart from the spirit
22 of the invention, they are intended to be included within
23 the scope thereof which is assessed only by a fair
24 interpretation of the following claims.

1 Having fully described the invention in such clear and
2 concise terms as to enable those skilled in the art to
3 understand and practice the same, the invention claimed is: